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54 **CIRCUIT LAYOUT FOR CONTROLLING A CRUSTBREAKER**

57 Circuit layout for controlling a pneumatic cylinder (1) for a crustbreaking ram in an aluminium electrolysis cell, comprising:
a) Two limit switches (31, 39) for double-action pneumatic cylinder, an operating valve (8), which is driven by a pilot valve (17) and allows the pneumatic pressure to act on the pneumatic cylinder (1) through a stop valve and a non-stop valve (27, 61), with:
in a first position of the operating valve (8), the pneumatic cylinder (1) not being connected with the compressed air source (15) and the ram being in the start position, with the operating valve (8) taking the form of a two-way valve, which, after leaving the start position in the downward movement of the ram and reaching the lower position of a limit switch, can be moved into a second position:
b) a signal converter for a monitoring signal if the ram is in the start position, being returned to its initial position if the ram is not in the start position, and:
the pilot valve (17) being unable to be activated unless the monitoring signal is present, and:
following the activation of the operating valve, the monitoring signal remaining switched on until the ram moves in the direction of the start position, with the

monitoring signal not being switched on following a processing time, which corresponds to the period of time taken for the ram to pass from the start position to the end position and back to the start position.

c) a reset valve, via which the compressed air source is linked to the pneumatic cylinder to move the ram in the direction of the start position, with the start signal being repeated if the monitoring signal is switched on following a pre-settable return time, which corresponds to the period of time taken for the ram to reach the start position again:

d) a manometric switch (47) for a warning message following the return time if the pressure signal is switched on within a pre-set waiting time and for an alarm in the event that the pressure signal is not switched on within the pre-set waiting time.

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CIRCUIT LAYOUT FOR CONTROLLING A CRUSTBREAKER

DESCRIPTION

The discovery relates to a circuit layout for controlling a crustbreaker of an aluminium electrolysis cell.

Aluminium electrolysis cells are used in the extraction of primary aluminium. Aluminium oxide (alumina) is dissolved in the molten cryolite for electrolysis. In order to guarantee the efficiency of the electrolysis operation, the aluminium oxide concentration in the molten cryolite must be kept within narrow limits. Too little aluminium oxide leads to a so-called anode effect, which expresses itself in a large increase in the voltage at the edges of the bath for the molten cryolite. Too much aluminium oxide causes contamination effects on the bath base due to deposits of aluminium oxide.

In order to guarantee uniform operation, aluminium oxide must be continually added to the molten cryolite. To this effect, apertures are created in the molten crust covering the cryolite bath, through which aluminium oxide can be fed into the cryolite bath.

To do this, a crustbreaker is provided for, which comprises a ram which can be driven, for example, by a pneumatic cylinder, and which can be pushed into the molten crust from above. Hoppers are also provided for which are positioned near the ram, and by means of which aluminium oxide can be dosed into the aperture in the molten crust.

The addition of aluminium oxide is largely automated. The aluminium oxide can be fed in, for example, using a timed system, with the ram being automatically activated. It automatically extends, and when it reaches a lower end position it automatically travels back. This is when the aluminium oxide is fed in through the hoppers and by means of dosing apparatus. Such a procedure is described, for example, in EP 0 044 794 B1.

However, the disadvantage is that any irregularities in the operation of the crustbreaker, together with, for example, jammed rams or unbreakable molten crusts, can not be recognised.

The purpose of the present invention is therefore to prepare a circuit layout for controlling a crustbreaker which can be used to monitor the crustbreaker and to detect any errors automatically.

According to invention, the problem is solved by a circuit layout in accordance with Paragraph 1 of the claims. In order to control a double-acting pneumatic cylinder and drive the ram of a crustbreaker in an aluminium electrolysis cell, the cylinder is not

indexed by compressed air when the ram is in the start position. The pneumatic cylinder is indexed by compressed air in the following manner. Beginning from the start position, the ram is driven in the direction of an end position if a start signal is given, in the form of a pulse. This causes the cylinder to be indexed by compressed air in such a manner that the ram, beginning from the end position, is driven back towards the start position if the cylinder is in the end position. A monitoring signal is switched on if the ram is in the start position and reset if the ram is not in the start position. The start signal can not be switched on unless the monitoring signal is present. In the event that the monitoring signal remains switched on after the start signal has been switched on, the cylinder is indexed by compressed air in such a manner that the ram is moved in the direction of the start position, or the cylinder is not indexed by compressed air. In the event that, following the switching on of the start signal and the elapsing of a processing time, which corresponds to the period of time during which the ram, starting from the start position, runs through to the end position, and should have returned to the start position again, the monitoring signal is not switched on, the cylinder is indexed by compressed air in such a manner that it is moved in the direction of the start position. In the event that, following the elapsing of a return period of time which corresponds to the period within which the ram should have returned to the start position, the monitoring signal is switched on, the start signal is also reset and, should the monitoring signal not be present, in the event that the monitoring signal is switched on within a pre-set waiting time, a warning message is transmitted. In the event that the monitoring signal is not switched on within the pre-set waiting time, an alarm is set off.

The circuit layout makes it possible to monitor all the movement procedures of the crustbreaker. Some frequent malfunctions can be eliminated once the problem has been identified.

One possible problem can be that the crustbreaker ram is not extending when the start signal is switched on. In order to determine whether this problem is present, the monitoring signal is checked. If it remains switched on following a period of time within which, according to experience, the ram should have left the start position, the assumption can be made that the ram has not extended. However, it is also conceivable that the switch which sets the monitoring signal is faulty. If this problem arises, the pneumatic cylinder is indexed by compressed air in such a manner that the ram is driven back into the start position or retained in it.

A further malfunction arises if the ram, having left the start position, has not returned to it. In this case, the ram is driven back until it reaches the start position. If the ram reaches the start position, the assumption can be made that it has not broken through the crust. New attempts are then made to break through the crust. Preferably, a maximum of five attempts are possible, after which a warning signal is transmitted so that the operators can break through the crust manually.

In the event that, after leaving the start position, the ram returns to it only after a delay - i.e., a period of time which, according to experience, is sufficient for the ram to move initally from the start position into the end position and back into the start position is

exceeded - it should be assumed that slag deposits have formed on the ram, which are slowing down the ram's movement as it breaks through the crust.

In the event that the ram can not be driven back, it should be assumed that the ram has become stuck in the crust. In this event, an alarm signal is transmitted.

The structure of a circuit layout to control a crustbreaker of an electrolysis cell comprises a double-acting pneumatic cylinder to drive a ram, an operating valve in the form of a distributing valve with four connections and two switch positions, a first connection being linked to a compressed air source, a second to an aeration system, a third to a piston-side cylinder cavity in the pneumatic cylinder and a fourth to a con- rod side cylinder cavity in the pneumatic cylinder. In a first switch position of the operating valve, the piston-side cylinder cavity of the operating valve is linked to the aeration system and the con-rod side cylinder cavity is linked to the compressed air source, and in a second switch position of the operating valve the piston-side cylinder cavity is linked to the compressed air source and the con-rod side cylinder cavity to the aeration system, a stop valve between the fourth connection of the operating valve and the con-rod side cylinder cavity, which, in a first position, releases the flow and, in a second position, closes the flow off, a pilot valve, through the short-time activation of which the operating valve can be moved over into the second position, and a first limit switch, which is activated as soon as the cylinder con-rod is in a first end position (start position), with the stop valve being transferrable into the second position by the activation of the first limit switch, a second limit switch, which is activated as soon as the cylinder con-rod is in a second end position (end position), with the operating valve being transferrable into the first switch position by the activation of the second limit switch, and a manometric switch which is switchable, depending on an air pressure, to activate the operating valve.

The operating valve is wired up to the pneumatic cylinder in such a manner that the movement cycle of the cylinder is automated. It is merely necessary to transmit a brief start signal. The cylinder than initially travels from the start position into the end position, and automatically returns to the start position. This makes it possible to keep the time during which the ram is in contact with the molten cryolite as short as possible.

The manometric switch which converts the air pressure in the control circuit of the stop valve into an electrical signal makes it possible to determine the position of the ram. The electrical signal can be passed on to a control and assessment unit. Moreover the manometric switch can be positioned sufficiently far away from the electrolysis cell, since operating electrical switches in close proximity to the electrolysis cell is problematic.

The pilot valve is preferably made up of a distribution valve with three connections and two switch positions, with a first connection being linked to a compressed air source, a second to an aeration system and a third to the operating valve, in order to activate it, and with the pilot valve, in a non-activated state, being indexed in the direction of a first switch position and, in an activated state, being indexed in the direction of a second switch position, and with the compressed air source being blocked and the operating

valve being connected to the aeration system in the first switch position and with the aeration system being blocked and the operating valve being linked to the compressed air source in such a manner that the operating valve is indexed in the direction of the second switch position.

The limit switch can be made up of a distribution valve with three connections and two switch positions, with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the stop valve, in order to activate it, and with the first limit switch, in a non-activated state, being indexed in the direction of a first switch position and, in an activated state, being indexed in the direction of a second switch position, and with the compressed air source being blocked in the first switch position and the stop valve being linked to the aeration system in such a manner that the stop valve is indexed in the direction of the first switch position, and with the aeration system being blocked in the second switch position and the stop valve being linked to the compressed air source in such a manner that the stop valve is indexed to the second switch position.

The second limit switch can be made up of a distribution valve with three connections and two switch positions, with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the operating valve, in order to activate it, and with the second limit switch, in a non-activated state, being indexed in the direction of a first switch position and, in an activated state, being indexed in the direction of a second switch position, and with the compressed air source being blocked in the first switch position and the operating valve being linked to the aeration system, and with the aeration system being blocked in the second switch position and the operating valve being linked to the compressed air source in such a manner that the operating valve is indexed in the direction of the first switch position.

In order for it to be possible to move the ram back to the start position from any other position, a reset valve is provided for, which takes the form of a distribution valve, provided with three connections and two switch positions, with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the operating valve, in order to activate it, and with the reset valve, in a non-activated state, being indexed in the direction of a first switch position and, in an activated state, in the direction of a second switch position, and with the compressed air source being blocked in the first switch position and the operating valve being linked to the aeration system, and with the aeration system being blocked in the second switch position and the operating valve being linked to the compressed air source in such a manner that the operating valve is indexed in the direction of the first switch position.

In order to immobilise the crustbreaker ram if the system air pressure fails, a non-stop valve is positioned between the fourth connection of the operating valve and the con-rod side cylinder cavity, which is linked to a compressed air source in such a manner that it is indexed by the air pressure to a first switch position in which the flow of the fourth connection of the operating valve to the con-rod side cylinder cavity is released and that,

should the air pressure be absent, it is indexed to a second switch position in which the flow is blocked.

Some preferred embodiments are clarified below in relation to the illustrations, in which:

Fig. 1 shows a circuit layout for controlling a crustbreaker
Fig. 2 shows a detailed Section A from Fig. 1
Fig. 3 shows the first section of a flow chart for a procedure for controlling a crustbreaker
Fig. 4 shows the second section of a flow chart for controlling a crustbreaker
Fig. 5 shows the third section of a flow chart for controlling a crustbreaker

Fig. 1 shows a circuit layout for controlling a crustbreaker. The crustbreaker is driven through a double-acting pneumatic cylinder, 1. The pneumatic cylinder, 1, has a piston-side cylinder cavity, 2, and a con-rod side cylinder cavity, 3. When the piston-side cylinder cavity, 2, is pressurised, a piston, 4, together with a piston rod, 5, is initially moved from a start position, 6, in the direction of an end position, 7. When the con-rod side cylinder cavity, 3, is pressurised, the con-rod, 5, moves back to the start position, 6.

To control the pneumatic cylinder, 1, an operating valve, 8, is provided for, in the form of a distribution valve with four connections, 9, 10, 11, 12, and two switch positions, 13, 14. A first connection, 9, is linked to a compressed air source, 15, a second connection, 10, to an aeration system, 16, a third connection, 11, to the piston-side cylinder cavity, 2, of the pneumatic cylinder, 1, and a fourth connection, 12, to the con-rod side cylinder cavity, 3, of the pneumatic cylinder, 1. In a first switch position, 13, of the operating valve, 8, the piston-side cylinder cavity, 2, is linked to the aeration system, 16, and the con-rod side cylinder cavity, 3, to the compressed air source, 15. In a second switch position, 14, of the operating valve, 8, the piston-side cylinder cavity, 2, is linked to the compressed air source, 15, and the con-rod side cylinder cavity, 3, to the aeration system, 16.

To activate the operating valve, a pilot valve, 17, is provided for, which is made up of a distribution valve with three connections, 18, 19, 20, and two switch positions, 21, 22. A first connection, 18, is linked to a compressed air source, 23, a second connection to an aeration system, 24, and a third connection, 20, to the operating valve, 8. In a first switch position, 21, the compressed air source, 23, is blocked and the operating valve, 8, is linked to the aeration system, 24. In a second switch position, 22, the aeration system, 24, is blocked and the operating valve, 8, is linked to the compressed air source, 23. The pilot valve, 17, is indexed through a spring element, 25, in the direction of the first switch position, 21. Through an electro-magnetic activating system, 26, the pilot valve, 17, can be transferred into the second switch position, 22. If the pilot valve, 17, is in the second switch position, 22, then the operating valve, 8, is linked to the compressed air source, 23, in such a manner that the operating valve, 8, is transferred into the second switch position, 14.

A stop valve, 27, is provided for between the fourth connection, 12, of the operating valve, 8, and the con-rod side cylinder cavity, 3, of the pneumatic cylinder, 1, the said valve, in a first position, 28, releasing the flow between the fourth connection, 12, and the

con-rod side cylinder cavity, 3, and, in a second position, 29, closing the flow off. A spring element, 30, indexes the stop valve, 27, in the direction of the first switch position, 28. To activate the stop valve, 27, it is linked to a first limit switch, 31, which is made up of a distribution valve with three connections, 32, 33, 34, and with two switch positions, 35, 36. A first connection, 32, is linked to the compressed air source, 15, a second connection, 33, to an aeration system, 37, and a third connection, 34, to the stop valve, 27. In a first switch position, 35, the compressed air source, 15, is blocked and the stop valve, 17, is linked to the aeration system, 37. In a second switch position, 36, the aeration system, 37, is blocked and the stop valve, 17, is linked to the compressed air source, 15. The first limit switch, 31, is indexed by a spring element, 38, in the direction of the first switch position, 35. If the piston rod, 5, is in the start position, 6, the first limit switch, 31, is transferred to the second switch position, 36, through a cam (not shown here) on the con-rod, 5. The stop valve, 27, is then linked to the compressed air source, 15, in such a manner that the stop valve, 27, is transferred into its second switch position, 29.

To activate the operating valve, 8, a second limit switch, 39, is also provided, which is represented by a distribution valve with three connections, 40, 41, 42, and with two switch positions, 43, 44. A first connection, 40, is linked to the compressed air source, 15, a second, 41, to an aeration system, 45, and a third, 42, to the operating valve, 8. In a first switch position, 43, the compressed air source, 15, is blocked and the operating valve, 8, is linked to the aeration system, 45. In a second switch position, 44, the aeration system, 45, is blocked and the operating valve, 8, is linked to the compressed air source, 15. By means of a spring element, 46, the second limit switch, 39, is indexed in the direction of the first switch position. If the piston rod, 5, of the pneumatic cylinder, 1, is in the end position, 7, the second limit switch, 39, is transferred into the second switch position, 44, through a cam (not shown here) on the con-rod, 5. In this position, the operating valve, 8, is linked to the compressed air source, 15, in such a manner that the operating valve, 8, is transferred into its first switch position, 13.

A pressure switch, 47, is linked to a control circuit, 48, between the third connection of the first limit switch, 21, and the stop valve, 27. If there is a pneumatic pressure in the control circuit, 48, an electrical switch in the manometric switch, 47, is switched. Thus an electrical signal can be passed on to a control and assessment unit.

A reset valve is also provided for to activate the operating valve, 8, the said valve being represented by a distribution valve with three connections, 50, 51, 52 and with two switch positions, 53, 54. A first connection, 50, is linked to the compressed air source, 23, a second connection, 51, to an aeration system, 55, and a third connection, 52, to the operating valve, 8. In a first switch position, 53, the compressed air source, 23, is blocked and the operating valve, 8, is linked to the aeration system, 55. In a second switch position, 54, the aeration system, 55, is blocked and the operating valve, 8, is linked to the compressed air source, 23. A spring element, 56, indexes the reset valve, 49, in the direction of the first switch position, 53. The reset valve, 57, can be transferred into the second switch position, 44, by means of an electro-magnetic activation system, 57. In this

switch position, 54, the operating valve, 8, is linked to the compressed air source, 23, in such a manner that the operating valve, 8, is transferred into the first switch position, 13.

The operating valve, 8, can thus, by the activation of the reset valve, 49, or the limit switch, 39, be transferred into the first switch position, 13. A control circuit, 58, which is linked to the third connection, 52, of the reset valve, 39, and a control circuit, 59, which is linked to the third connection, 42, of the second limit switch, 39, lead to a shuttle valve, 60. Depending on the air pressures in the control circuits, 58, 59, the control circuit in which a higher air pressure is present is linked to the operating valve, 8.

In order to stabilise the pneumatic cylinder, 1, should the system pressure fail, a non-stop valve, 61, is provided for between the fourth connection, 12, of the operating valve, 8, and the con-rod side cylinder cavity, 3, of the pneumatic cylinder, 1, near the stop valve, 27, the said non-stop valve, in a first switch position, 62, closing off the flow from the operating valve, 8, to the con-rod side cylinder cavity, 3, and, in a second switch position, 63, releasing the flow. By means of a spring element, 64, the non-stop valve, 61, is indexed in the direction of the first switch position, 62. Moreover, the non-stop valve, 61, is linked to the compressed air source, 15, in such a manner that, when air pressure is present, the non-stop valve, 61, is transferred into the second switch position, 63. As soon as the system pressure of the air pressure source, 15, drops, the non-stop valve is transferred into the first switch position through the spring element, 64, and thus the pneumatic cylinder, 1, is fixed.

Fig. 2 shows a detailed section A from Fig. 1, which is explained in greater detail below. The pneumatic cylinder, 1, contains a piston rod, 5, with two limit switches, 31, 39, which are coupled to sensors, S1, S2. The pneumatic cylinder is in the start position, 6 (dotted lines), and is thus linked to a compressed air source, 15, through circuits.

Provided that a start signal, 66, is emitted in the CPU, 65, via the amplifier, 67, to the pilot valve, 17, the operating valve, 8, clears the circuit, 68, so that pneumatic energy reaches the left side of the piston rod, 5.

After a time, T1, which is selected in the CPU, 65, a check is carried out to see if the piston, 4, has left the start position (sensor, S1). A message is transmitted to the pressure switch, 47, through the first limit switch, 31.

Once the end position, 7, of the piston rod, 5, has been reached (dotted line), the second limit switch, 39, is activated, and the sensor, S2, gives a signal to the operating valve, 8, to make it possible to switch to the circuit, 69, to return the piston, 4, to the start position.

During this time, the CPU, 65, is checking whether the time, T2, from the start of the piston, 4, to its return lies within the set tolerance. Should the time be excessive, a reset pulse is switched on by the reset valve, 49, so that the piston, 4, returns to the initial position, 6, and the same process is repeated once again. These processes are repeated until the crust is broken, with an alarm being given and a message being transmitted locally or centrally.

Another possible error is displayed via the CPU if the crustbreaker spindle remains stuck in the molten mass. The cylinder is then compulsorily reset, with the piston, 4, returning to the start position, by means of the reset valve, 49, and the operating valve, 8.

If the compulsory reset procedure does not work, the reset function can be repeated several times. Should this repetition prove fruitless, an alarm is given, and a message is transmitted locally or centrally.

It is, of course, possible to block the piston, 4, in the event of an alarm. This is carried out through a stop valve, 27, or a non-stop valve, 61, which is incorporated into the circuit, 69, between the operating valve, 8, and the pneumatic cylinder, 1.

Any malfunction of the sensors, S1, S2, also leads to a message being sent back to the CPU 65, which triggers an alarm, and the faulty crustbreaker is displayed in the monitoring centre, together with the possible type of fault. Even if no message is sent back from the sensor, S1, and displayed before the start, an alarm is transmitted locally or centrally. The following types of error can be considered: sensor, S1, faulty, signal convertor and sensor, 1, faulty, or amplifier, 67, faulty. Compressed air losses can also be recognised by the system in this case.

If the crustbreaker cylinder no longer reverses its direction of travel automatically when it reaches its end point, then the sensor, S1, may be faulty, and the piston, 4, remains stuck in the end position. The control program in the circuit layout then interprets the situation as an unbroken crust, whereupon the corresponding reset function is carried out. After several repetitions, an alarm is given, and a message is transmitted locally or centrally.

In the context of the supervision which takes place, it is recognised that a sensor fault has occurred, and an emergency program is implemented. Under this program, the crustbreaker cylinder is cyclically operated using start and reset signals, or is moved by means of a manual valve, 70, with no guarantee of any automatic monitoring of the reversal of direction of the cylinder in the end positions. This emergency program continues to operate for as long as the malfunction is present. Once the crustbreaker cylinder has been replaced, automatic operation can be resumed.

Figs. 3 to 5 show a flow chart which reflects a process for controlling a crustbreaker. Actions are positioned within a rectangle, decisions within a lozenge, and comments or messages within an octagonal frame. Initially, a command is given to break the crust by a higher-ranking control and assessment unit. A counter is hereupon set to 1. The monitoring signal is consequently checked. Should no monitoring signal be present, it should be assumed that the ram is not in the top initial position - i.e., in the start position. The process is interrupted, and an appropriate warning message is transmitted. Should the monitoring signal be switched on, a timer is started and a start signal is transmitted for a period of 1 second. When 2 seconds have elapsed, a check is carried out to see whether the monitoring signal is switched on. If the monitoring signal is no longer switched on, it should be assumed that the ram has started off satisfactorily and left the start position. Should the monitoring signal be switched on, it should be assumed that the ram is still in

the start position, or that the switch for setting the monitoring signal is faulty. Thereupon a cycle is started to reset the ram. To this effect, the start signal is initially set for 1 second and the ram is moved out. When 5 seconds have elapsed, a reset signal is set, through which the ram is moved back into the start position.

Starting from position II in Fig. 3, the flow chart is continued in Fig. 4. If the ram has started out satisfactorily, checks are carried out, starting after 4. 5 seconds and ending after 25 seconds, to see whether the monitoring signal has been reset. It should be assumed that, if the cycle is satisfactory, the ram should have returned to the start position. If the monitoring signal is switched on, the ram has returned satisfactorily and the cycle is completed. If the monitoring signal is not switched on, a reset signal is switched on in order to transfer the ram back to the start position. A timer is started, and after 4 seconds a check is carried out to see whether the monitoring signal is switched on. If the cycle is satisfactory, the ram should have returned to the start position after 4 seconds. If the monitoring signal is switched on, the ram has returned to the start position. It should be assumed that the crust has not been broken. 5 more attempts are made to break through the crust, and each time the display on the counter increases by 1 and the cycle starts again from the beginning. When the counter has reached 5, a message is transmitted that the crust has not been broken, and the process is interrupted.

If, following the switching on of the reset signal, the monitoring signal is not switched on within 4 seconds, additional checks are carried out, starting after 4. 5 seconds and ending after 25 seconds. If a monitoring signal is present then, it should be assumed that slag deposits have arisen on the ram which are delaying the cycle. If the monitoring signal is not present, it should be assumed that the ram has jammed in the crust. In that case, an alarm is transmitted.

LEGEND

1	Pneumatic cylinder
2	Piston-side cylinder cavity
3	Con-rod side cylinder cavity
4	Piston
5	Con-rod
6	Start position
7	End position
8	Operating valve
9	First connection
10	Second connection
11	Third connection
12	Fourth connection
13	First switch position
14	Second switch position
15	Compressed air source
16	Aeration system
17	Pilot valve
18	First connection
19	Second connection
20	Third connection
21	First switch position
22	Second switch position

23 Compressed air source

24 Aeration system

25 Spring element

26 Electro-magnetic activation

27 Stop valve

28 First switch position

29 Second switch position

30 Spring element

31 First limit switch

32 First connection

33 Second connection

34 Third connection

35 First switch position

36 Second switch position

37 Aeration system

38 Spring element

39 Second limit switch

40 First connection

41 Second connection

42 Third connection

43 First switch position

44 Second switch position

45 Aeration system

46	Spring element
47	Manometric switch
48	Control circuit
49	Reset valve
50	First connection
51	Second connection
52	Third connection
53	First switch position
54	Second switch position
55	Aeration system
56	Spring element
57	Electro-magnetic activation
58	Control circuit
59	Control circuit
60	Shuttle valve
61	Non-stop valve
62	First switch position
63	Second switch position
64	Spring element
65	CPU
66	Start signal
67	Amplifier
68	Circuit

69	Circuit
70	Manual valve
S1, S2	Sensors
T1, T2	Time

CLAIMS

1. Circuit layout for controlling a pneumatic cylinder (1) for a crustbreaker ram in an aluminium electrolysis cell, comprising

   a) two limit switches (31, 39) for the double-acting pneumatic cylinder, an operating valve (8), which is driven by a pilot valve (17) and which allows the pneumatic pressure to act on the pneumatic cylinder (1) through a stop valve and a non-stop valve (27, 61), with

   the pneumatic cylinder (1), in a first position of the operating valve (8), not being linked to the compressed air source (15), and with the ram being in a start position, and with

   the operating valve (8) taking the form of a two-way valve which, after leaving the start position, can be moved into a second position, as part of the downwards movement of the ram and of arriving at the lower position of a limit switch,

   b) a signal converter for a monitoring signal when the ram is in the start position, which is reset when the ram is no longer in the start position, with

   the pilot valve (17) not being activable unless the monitoring signal is present, and with

   the monitoring signal remaining switched on, following the activation of the operating valve, until the ram moves in the direction of the start position, and with

   the monitoring signal not being switched on, following the activation of the operating valve (8), and after the elapsing of a processing time which corresponds to the period of time within which the ram, starting from the start position, should have run through the end position and returned to the start position,

   c) a reset valve linking the pressure source with the pneumatic cylinder to move the ram in the direction of the start position, and with

   the start signal being repeated if the monitoring signal is switched on, following the elapsing of a pre-set return time which corresponds to the period of time within which the ram has returned to the start position,

   d) a manometric switch (47) for a warning message, following the elapsing of the return time, if the pressure signal is switched on within a pre-set

waiting time, and for an alarm in the event that the pressure signal is not switched on within the pre-set waiting time.

2. Circuit layout as Paragraph 1,

distinguished by the fact

that, following the initial switching on of the start signal in a CPU, the start signal is switched on a maximum of five times in succession and thereafter a warning is transmitted.

3. Circuit layout as Paragraph 1 or 2,

distinguished by the fact

that, following the switching on of the start signal, the monitoring signal remains switched on and the CPU links the pneumatic cylinder on the falling side of the ram with the compressed air connection and, following the elapsing of a pre-set period of time, the pneumatic cylinder is indexed by compressed air on the stroke side, so that the ram is moved in the direction of the start position.

4. Circuit layout of an aluminium electrolysis cell, comprising

a double-acting pneumatic cylinder to drive a ram,

an operating valve (8) in the form of a distribution valve with four connections and two switch positions, and with a first connection (9) to a compressed air source (15), a second connection (10) to an aeration system (16), a third connection (11) to a piston-side cylinder cavity (2) of the pneumatic cylinder (1) and a fourth connection (12) to a con-rod side cylinder cavity (3) of the pneumatic cylinder (1),

with the piston-side cylinder cavity (2), in a first switch position (13) of the operating valve (8), being linked to the aeration system (16) and the con-rod side cylinder cavity (3) being linked to the compressed air source (15), and with the piston-side cylinder cavity (2), in a second switch position (14) of the operating valve (8), being linked to the compressed air source (15) and the con-rod side cylinder cavity (3) being linked to the aeration system (16),

a stop valve (27) between the fourth connection (12) of the operating valve (8) and the con-rod side cylinder cavity (3) which, in a first position (21), releases the flow and, in a second position (22), closes off the flow,

a pilot valve (17), through the brief activation of which the operating valve (8) can be transferred into the second position,

a first limit switch (31) which is activated as soon as the cylinder piston rod (5) is in a first end position (start position), and with the stop valve being transferable into the second position when the first limit switch (31) is activated,

`a second limit switch (39) which is activated as soon as the cylinder piston rod (5) is in a second end position (end position), and with the operating valve (8) being transferable into the first switch position when the second limit switch (39) is activated,

a manometric switch (47) which is switchable, depending on an air pressure, to activate the stop valve (27).

5. Circuit layout as Paragraph 4,

distinguished by the fact

that the pilot valve (17) takes the form of a distribution valve with three connections and two switch positions, and with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the activation of the operating valve (8), and with the pilot valve (17) being indexed, in a non-activated state, in the direction of a first switch position and, in an activated state, in the direction of a second switch position, and with the compressed air source being blocked in the first switch position and the operating valve (8) being linked to the aeration system, and with, in the second switch position, the aeration system being blocked and the operating valve (8) being linked to the compressed air source in such a manner that the operating valve (8) is indexed in the direction of the second switch position.

6. Circuit layout as Paragraph 4 or 5,

distinguished by the fact

that the first limit switch takes the form of a distribution valve with three connections and two switch positions, and with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the activation of the stop valve, and with the first limit switch, in a non-activated state, being indexed in the direction of a first switch position and, in an activated state, in the direction of a second switch position, and with, in the first switch position, the compressed air source being blocked and the stop valve being linked to the aeration system in such a manner that the stop valve is indexed in the direction of the first switch position, and with, in the second switch position, the aeration system being blocked and the stop valve being linked to the compressed air source in such a manner that the stop valve is indexed to the second switch position.

7. Circuit layout as one of Paragraphs 4 to 6,

distinguished by the fact

that the second limit switch is represented by a distribution valve with three connections and two switch positions, and with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the operating valve (8) in order to activate it, and with the second limit switch, in a non-activated state, being indexed to a first switch position and, in the activated state, in the direction of a second switch position, and with the compressed air source being blocked in the first switch position and the operating valve (8) being linked to the aeration system, and with the aeration system being blocked in the second switch position and the operating valve (8) being linked to the compressed air source in such a manner that the operating valve (8) is indexed in the direction of the first switch position.

8. Circuit layout as one of Paragraphs 4 to 7,

distinguished by the fact

that a reset valve, in the form of a distribution valve, is provided for, with three connections and two switch positions, and with a first connection being linked to a compressed air source, a second connection to an aeration system, and a third connection to the activation of the operating valve (8), and with the reset valve, in a non-activated state, being indexed in the direction of a first switch position and, in the activated state, in the direction of a second switch position, and with the compressed air source, in the first switch position, being blocked and the operating valve (8) being linked to the aeration system, and with the aeration system, in the second switch position, being blocked and the operating valve (8) being linked to the compressed air source in such a manner that the valve is indexed in the direction of the first switch position.

9. Circuit layout as one of Paragraphs 4 to 8,

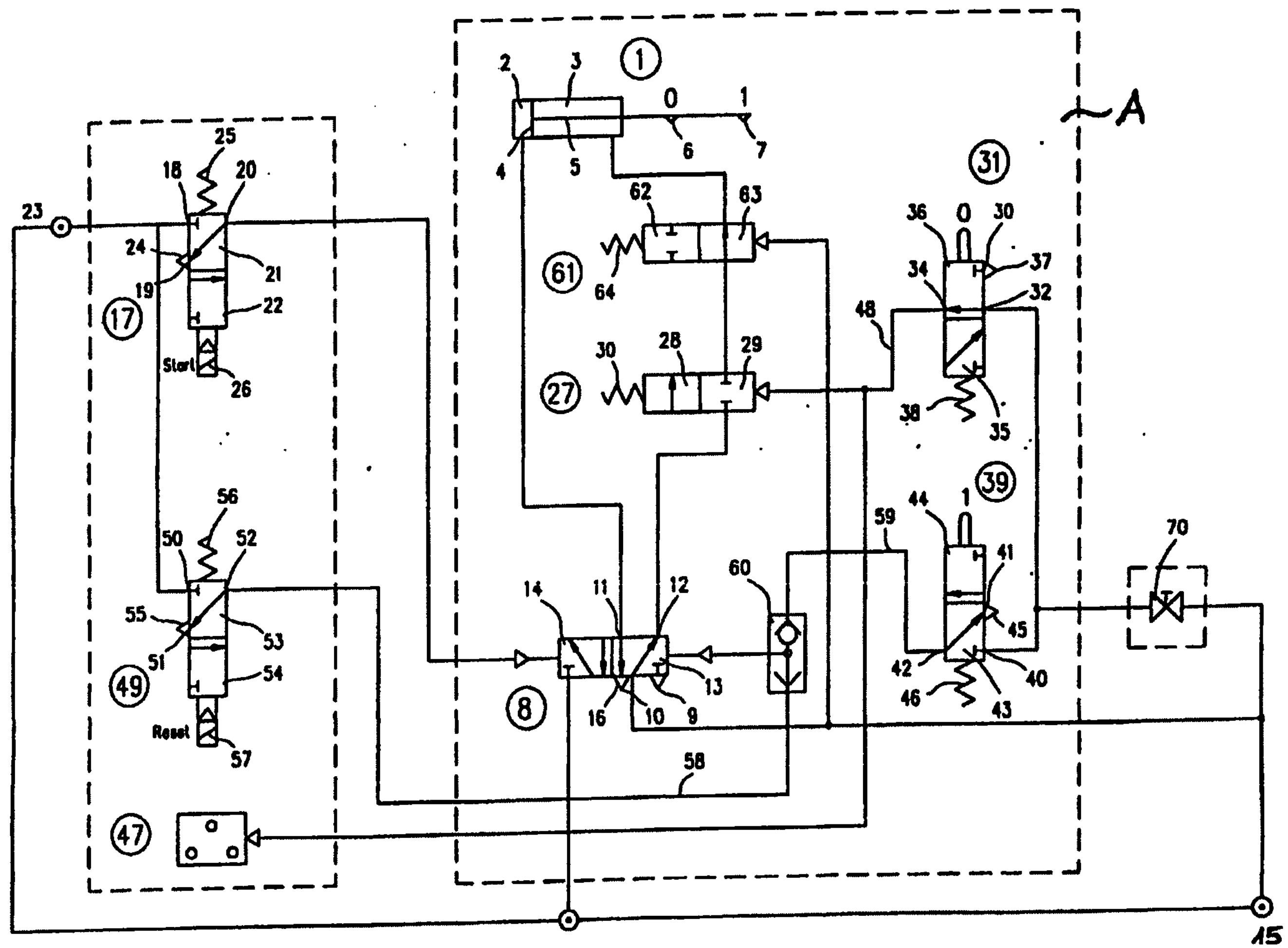
distinguished by the fact

that a non-stop valve (61) is positioned between the fourth connection of the operating valve (8) and the con-rod side cylinder cavity, the said valve being linked to a compressed air source in such a manner that it is indexed by the air pressure to a first switch position in which the flow from the fourth connection of the operating valve (8) to the con-rod side cylinder cavity is released, and that, should the air pressure not be present, the said valve is indexed to a second switch position, in which the flow is blocked.

(Text on diagrams:
"Rückm. Sensor" = "Return sensor", "Umschalter" = "Reversing switch", "Kruste brechen" = "Break crust", "Kontroll-signal gesetzt?" = "Monitoring signal switched on?", "Ja" = "Yes", "Nein" = "No", "Kontrollsignal nicht gesetzt (Startposition)" = "Monitoring signal not switched on (start position)", "Timer starten" = "Start timer",

"1 sec. Startsignal setzen (Stößel senken)" = "Switch on 1 sec. start signal (lower ram)", "Nach 2 sec. Kontrollsignal gesetzt?" = "Monitoring signal switched on after 2 sec.?", "Also ist Stößel ordnungsgemäß losgefahren" = "Ram has therefore moved off satisfactorily", "Stößel bleibt in oberen Ausgangsstellung (Startposition) oder Schalter ist defekt" = "Ram still in start position or switch faulty", "Stößel zurückfahren mit RESET" = "Reset ram using RESET", "Resetsignal setzen" = "Switch on reset signal", "Nach 4,5 bis 25 sec. Kontrollsignal gesetzt?" = "Monitoring signal switched on from 4.5 seconds to 25 seconds?", "Stößel ordnunsgemäß gefahren?" = "Has ram moved off satisfactorily?", "Resetsignal setzen" = "Switch on reset signal", "Nach 4 sec. Kontrollsignal gesetzt?" = "Monitoring signal switched on after 4 seconds?", "Meldung: "Elefantenfuß!" = "Message: Elephant's foot!" "Alarmsignal (Hupe, Blitzer), Stößel fährt nicht zurück!" = "Alarm signal (hooter, flashing light), ram not returning!", "Meldung: Kruste nicht durchbrochen" = "Message: crust not broken", "Zähler" = "Counter", "Vermutl. Kruste nicht durchbrochen, xmalige Wiederholung der Prozedur" = "Crust apparently not broken, repeat procedure x times", "1 sec. Resetsignal setzen" = "Switch on 1 sec. reset signal", "Aktion" = "Action", "Entscheidung" = "Decision", "Bemerkung / Ausgabe" = "Note / version number")

21.06.99



A
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Reset
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64
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FIG 1

21.06.99

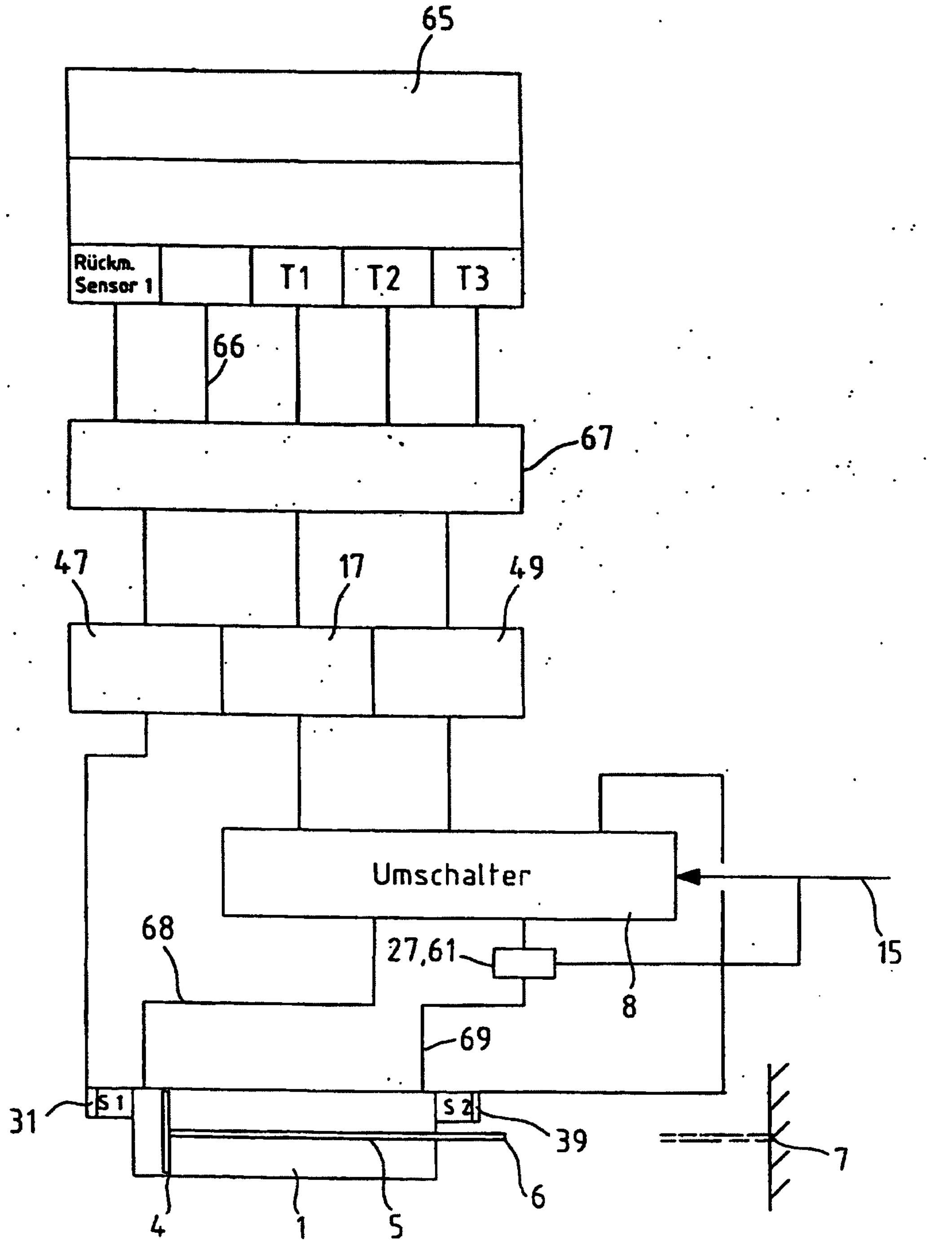

65
Rückm. Sensor 1
T1
T2
T3
66
67
47
17
49
Umschalter
68
27,61
8
15
69
31
S 1
S 2
39
7
6
4
1
5

Fig. 2

21.06.99

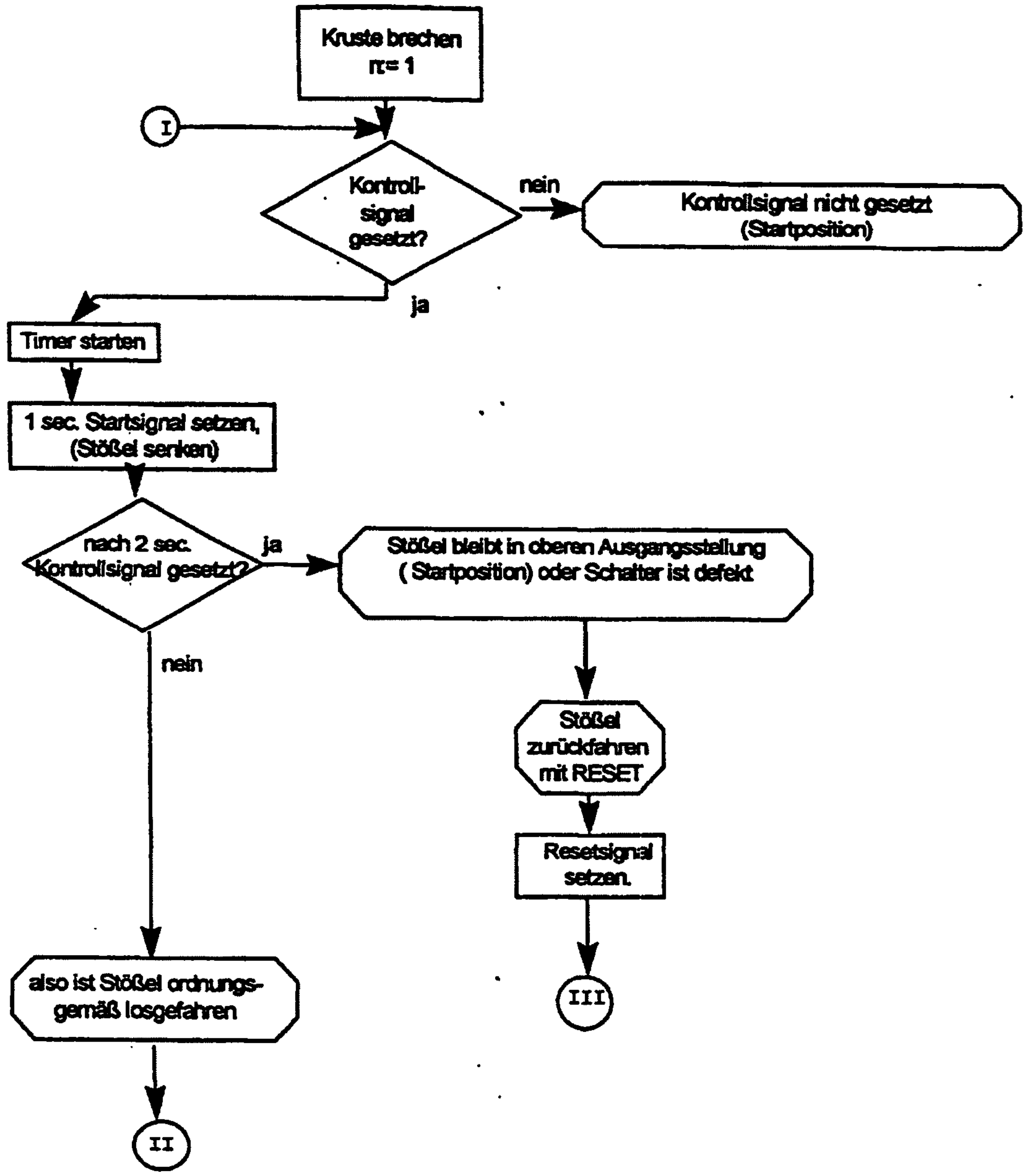
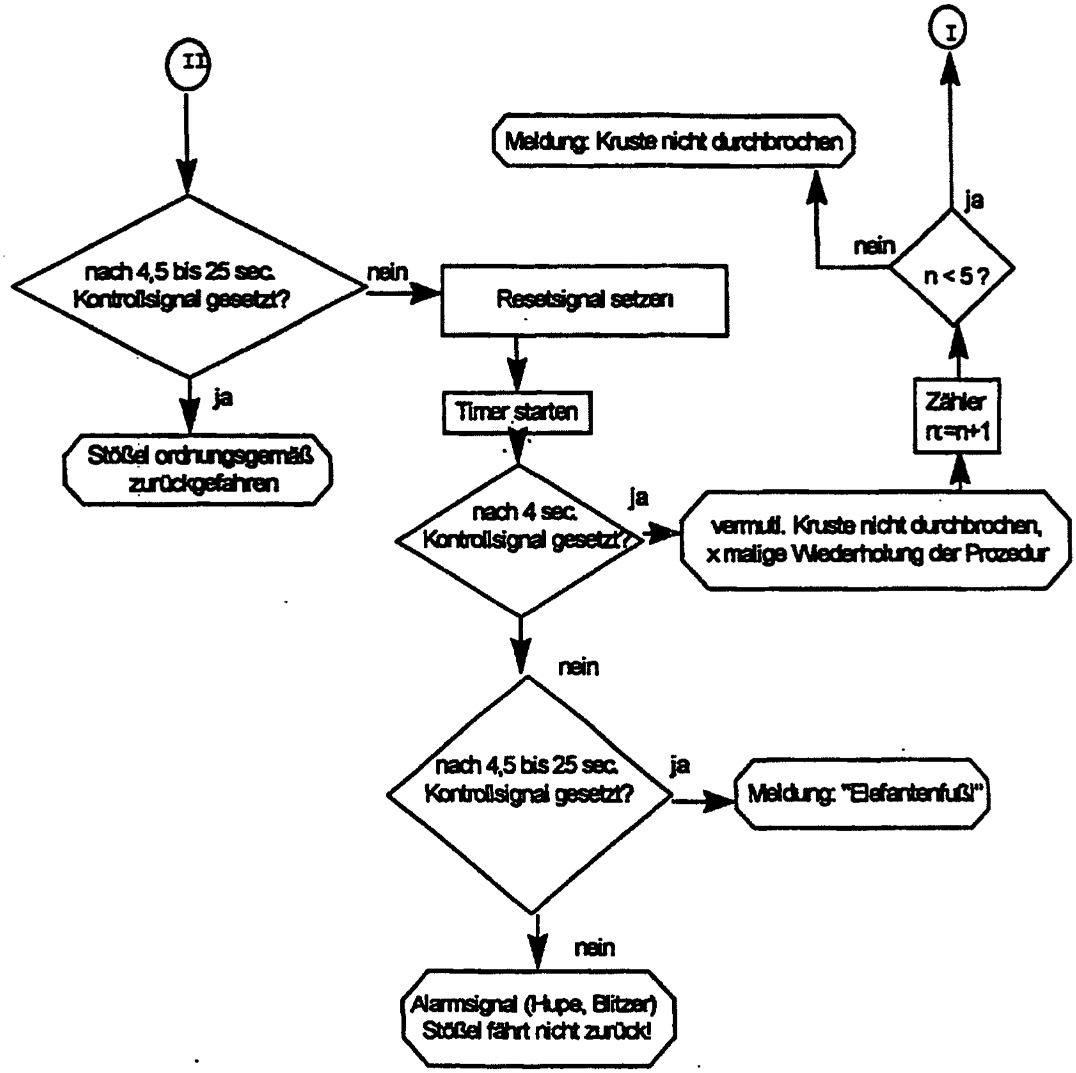

Kruste brechen
n = 1
I
Kontroll-
signal
gesetzt?
nein
Kontrollsignal nicht gesetzt
(Startposition)
ja
Timer starten
1 sec. Startsignal setzen,
(Stößel senken)
nach 2 sec.
Kontrollsignal gesetzt?
ja
Stößel bleibt in oberen Ausgangsstellung
(Startposition) oder Schalter ist defekt
nein
Stößel
zurückfahren
mit RESET
Resetsignal
setzen.
also ist Stößel ordnungs-
gemäß losgefahren
III
II

Fig. 3

21.06.99



II
nach 4,5 bis 25 sec. Kontroßsignal gesetzt?
nein
ja
Stößel ordnungsgemäß zurückgefahren
Resetsignal setzen
Timer starten
nach 4 sec. Kontroßsignal gesetzt?
ja
vermutl. Kruste nicht durchbrochen, x malige Wiederholung der Prozedur
Zähler n:=n+1
n < 5 ?
ja
nein
I
Meldung: Kruste nicht durchbrochen
nein
nach 4,5 bis 25 sec. Kontroßsignal gesetzt?
ja
Meldung: "Elefantenfuß"
nein
Alarmsignal (Hupe, Blitzer) Stößel fährt nicht zurück!

Fig. 4

21.06.99

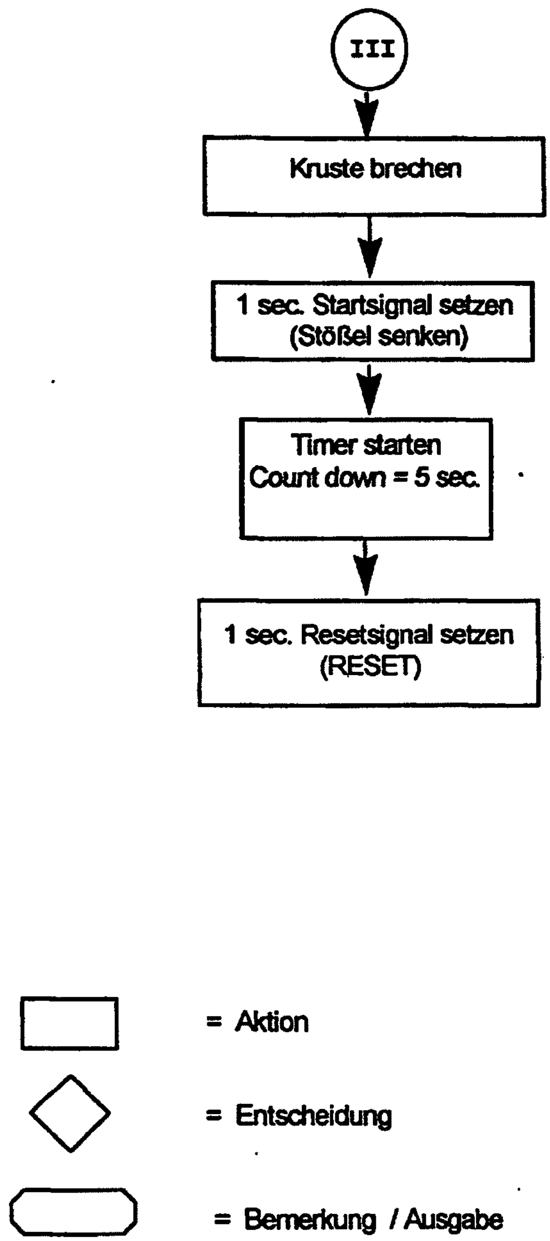

III
Kruste brechen
1 sec. Startsignal setzen
(Stößel senken)
Timer starten
Count down = 5 sec.
1 sec. Resetsignal setzen
(RESET)
= Aktion
= Entscheidung
= Bemerkung / Ausgabe

Fig. 5